INVESTIGATION 5-E

Mechanical and Thermal Energy

TARGET SKILLS

- **Performing and recording**
- **Analyzing and interpreting**
- **Identifying variables**

Before 1800, physicists and chemists did not know that a relationship existed between mechanical energy and heat. Count Rumford (Benjamin Thompson: 1753–1814) was the first to observe such a relationship, followed by Julius Robert Mayer (1814–1878). Rumford and Mayer made some very important discoveries. Mayer was unable to express himself clearly in writing, however, so his discoveries were overlooked. Eventually, James Prescott Joule (1818–1889) was credited with the determination of the mechanical equivalence of heat. In this investigation you will perform experiments similar to those of Mayer and Joule.

Problem

How much heat is produced when a mass of lead pellets is repeatedly lifted and dropped through a known distance?

Equipment

- balance
- thermometer (°C)
- lead shot
- cardboard or plastic tube with a small hole in the side, close to one end; the ends must be able to be closed
- metre stick
- small amount of masking or duct tape

Procedure

1. Determine the mass of the lead shot.
2. Place the lead shot into the tube and close up the tube. Let the tube sit upright on a desk for several minutes to allow the tube and its contents to come to room temperature. Make sure that the hole is close to the bottom of the tube.
3. Insert the thermometer or temperature probe through the hole in the tube and nestle the end in the lead shot. Measure and record the temperature.
4. Close the hole.
5. Measure the length of the tube.
6. Repeatedly invert the tube for several minutes, waiting only to allow the lead shot to fall to the bottom on each inversion. Keep track of the number of inversions.
7. Finish the inversions with the hole near the bottom of the tube. Remove the tape and measure the temperature of the lead shot. Record the final temperature.

Analyze and Conclude

1. What were the initial and final temperatures of the lead shot? What was the total mass of the lead shot?
2. Determine the quantity of heat gained by the lead shot (the specific heat capacity of lead is 128 J/kg·C°).
3. Determine the total distance through which the lead shot was lifted by the inversions and calculate the total gain in gravitational potential energy of the lead.
4. Determine the percentage of the gravitational potential energy that was converted into heat.
5. If the conversion into heat does not account for all of the gravitational potential energy gained by the lead shot, where else might some of the energy have gone?

Apply and Extend

6. How could this investigation be improved? Try to design a better apparatus and, if possible, carry out the investigation again.
7. Do research and write a summary of the work of Rumford, Mayer, and Joule on the mechanical equivalence of heat.